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GB 2217149 A EP 0629064 A1 WO 95/21492 A2
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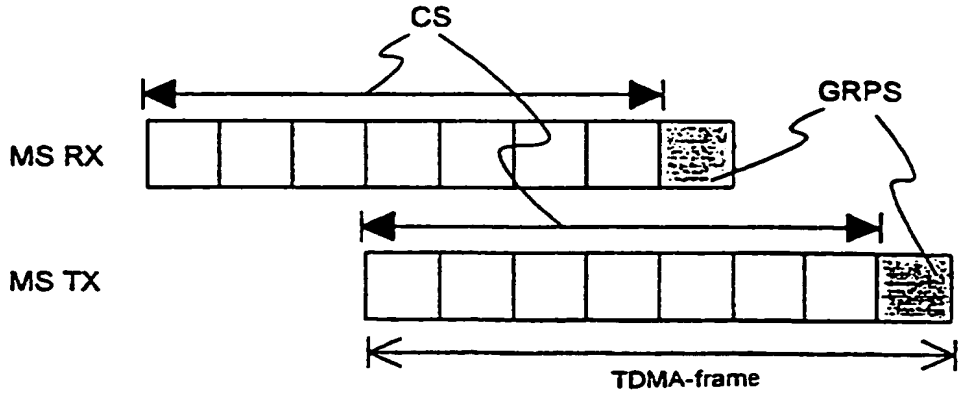
(54) TDMA communication arrangement with dynamic allocation of time slots between packet and circuit switched service

(57) The invention relates to a method aiming at dynamic division of the radio capacity in a TDMA system dynamically between packet radio service and circuit switched service. A basic number of time slots are reserved for packet radio service and the rest are reserved for circuit switched service. When the traffic requirement of packet radio service increases, information regarding this is obtained by means of a request from a mobile station or through traffic measurement at the base transceiver station. This information is used as a criterion in allocating more time slots to packet radio service.



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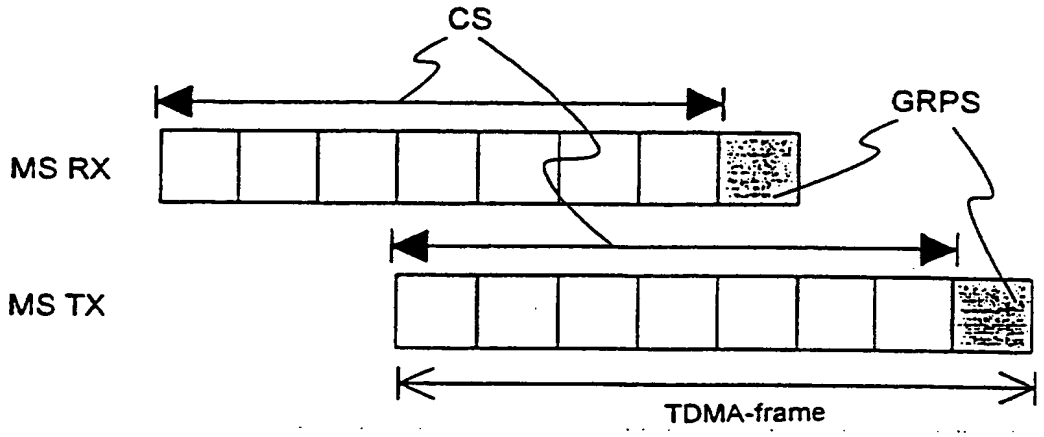

METHOD AND SYSTEM FOR CHANNEL ALLOCATION IN A RADIO SYSTEM

The present invention relates to a method and/or apparatus for allocating mode of usage of channels in a radio system. In particular the invention relates to a method and/or apparatus by which radio capacity is divided dynamically between packet radio service and circuit switched service in a TDMA system in which two-way traffic between base stations and mobile stations takes place in time slots on predetermined channels.

Most present-day cellular networks offer circuit switched services for speech and data. The available frequency band is divided between these services, all having equal priority. The network does not take into account whether the capacity is used for the transmission of speech or data.

Considering burst-form data services, circuit switching does not exploit the channel optimally. Therefore packet radio services are used alongside existing circuit switched services in cellular networks. Since the existing radio band cannot be expanded, packet radio services must be fitted into the same band as circuit switched services. Thus a certain amount of capacity has to be taken from circuit switched services for packet radio services.

In TDMA cellular systems, a radio band is usually divided into multiple frequency bands (FDMA, Frequency Division Multiple Access), and each frequency band is further divided into multiple time slots. Logical channels are transmitted in the physical time slots of the radio interface. In circuit switched cellular systems, all time slots are used for control signaling and for circuit switched traffic.

In accordance with the present invention there is provided a method for dynamic division of radio capacity between packet radio service and circuit switched service in a TDMA system in which two-way traffic between base transceiver stations and mobile stations takes place in time slots on prede-

termined channels, characterized in that in the basic mode a first predetermined number of time slots are reserved for packet radio service and a second predetermined number of slots are reserved for circuit-switched service, and that on the basis of a predetermined criterion, one or more additional free time slot/slots is/are allocated to packet radio service and/or circuit switched service, a corresponding number of time slots being deallocated from the other service. The invention provides a method by which the capacity of a radio channel can be better exploited. The method is used in determining the number of time slots allocated, on the one hand, to packet radio service and, on the other hand, to circuit switched service by allocating dynamically more capacity, i.e. more time slots, to the form of service requiring it at a given time.

Cases associated with this topic have been discussed previously in certain patent publications. One example of them is EP-26 11 27, which describes a time-sharing telecommunications system wherein the spectrum is exploited in a relatively efficient manner by dividing narrow-band radio frequency channels into at least two time slots, one to transmit coded speech signals and one to provide two-way transmission. However, this publication does not discuss the dynamic allocation of capacity, and it does not discuss packet radio services as such.

US patent 4 887 265 discloses a packet radio switched cellular system. In this system, a plurality of data calls can be switched to one and the same radio channel, whereby radio spectrum is saved. However, the publication mainly discusses the criteria of handoff. It does not discuss the dynamic allocation of capacity to packet radio and circuit switched services.

In accordance with the embodiments of the present invention, some basic number of time slots are reserved for packet radio service and a number of time slots for circuit switched service. If, for example, the traffic need of packet radio service increases, information regarding this is obtained through a request flagged by a mobile station or through traffic measurement by the base station,

whereupon this information is used as a criterion in the allocation of more time slots to this service. Such a request can be transmitted from a mobile station to a base station on a message or signaling channel (e.g. in call set-up signaling) or on a traffic channel, or it may be, for example, a short message output. The request may also be transmitted on a packet radio channel. The capacity required by each service is monitored in the base station system (BSS), which is in a known manner made up of base transceiver stations (BTS) and base station controllers (BSC), and from which information is transmitted to the mobile station regarding the channel configurations, i.e. the allocation of radio capacity (which channel is in the use of which service).

In the basic mode, all the time slots of the channel may be allocated to packet radio service when circuit switched service does not need capacity. In this case, one or several time slots are allocated to circuit switched service when a request for it is received, for example, from a mobile station in call set-up signaling. The base station controller (BSC) interprets the request from call set-up signaling and thereupon deallocates a channel which is in the use of packet radio service and allocates it to circuit switched service. Alternatively, a predetermined minimum number of time slots may be allocated in the basic mode to packet radio service, in which case more time slots will be allocated to packet radio traffic when it increases. When the number of time slots used for packet radio service is increased, the same number of time slots must be deallocated from circuit switched service in the same channel.

In a preferred embodiment of the invention, a certain minimum number of time slots are allocated in the basic mode to packet radio service, this minimum number being controlled on the basis of economic factors important for the traffic and/or the operator. The control can be coupled to the results of traffic measurement at the base transceiver station so that the control will be automatic. Alternatively, the operator may effect the control manually, and it may be based on historical information on traffic, etc.

In sparsely populated areas, or when the packet radio traffic of a TDMA cell is known to be very scanty or incidental, all of the time slots of the channel serving this cell may be allocated to circuit switched service. When an incidental need for packet radio traffic arises, information regarding this is transmitted to the base transceiver station, for example via the message channel of circuit switched service or via some other signaling channel, traffic channel or short-message output. For this purpose, also a specific message may be defined which the mobile station requesting the service will transmit to the base transceiver station. Preferably, however, existing messages are used for the request, for example a part of a call set-up message minimally modified, in which case also old services will function.

According to a preferred embodiment, more time slots for a service may be allocated in the same frequency band so that the maximum number of time slots allocated to the service will be equal to the number of time slots in the band. Alternatively, time slots may be additionally allocated to a service also in another channel.

The invention is thus a method for determining the number of time slots in use, on the one hand, for packet radio service and, on the other hand, for circuit switched service. The same mechanism can be used in parallel for FDMA bands and, on the other hand, also for only one frequency band. In downlink packet radio control channels, the radio channels allocated to packet switched use must be flagged very often in order to keep the mobile stations informed of the channels currently in force.

The invention is described in greater detail with the help of the following examples, with reference to the accompanying figure, which shows time slots in a TDMA frame.

In packet radio cellular systems, such as the GPRS system (General Packet Radio Service) standardizable for GSM/DCS 1800 systems, some of the

channels must be allocated to packet radio traffic. In this case the easiest method is that one time slot or multiple time slots is/are allocated permanently to packet radio traffic, and the rest of the time slots are reserved for circuit switched services. However, it is possible to divide the capacity even more flexibly between circuit switched service and packet radio service. The TDMA frame of one carrier wave of the GSM/DCS 1800 system is illustrated in the accompanying figure. The upper row shows the TDMA frame MS RX received by a mobile station and the lower row the transmission frame MS TX, offset with respect to time. The figure shows how one time slot in both downlink direction and uplink direction is reserved for packet radio service GPRS. The rest of the time slots are reserved for circuit switched (CS) calls.

Packet radio service in TDMA systems is quite new as compared with methods dividing a common frequency band, such as Aloha-based protocol. In TDMA radio systems using packet transmission, usually a plurality of users share one carrier wave time slot (frequency band) in both uplink and downlink directions. As in GSM/DCS 1800 systems, one time slot out of the eight time slots of a 200 kHz radio carrier wave could be allocated to the GRPS channel. About 25 kbit/s could be transferred in this selected time slot.

The capacity of one time slot may be insufficient. In this case the operator could allocate also another time slot, and even all time slots of a 200 kHz radio carrier wave, to packet radio service.

When multiple time slots are available, their use can be either combined or separate. In combined use, the time slots of the same carrier wave form for transmission a capacity pool shared by the mobile stations. One and the same mobile station may use multiple time slots in order to achieve a higher data rate for packet transmission. In separate use, each time slot is a separate physical packet transmission channel, and such channels are allocated to the mobile stations in a cell so as to achieve an even distribution of traffic. The distribution

may be controlled, for example, in the same manner as mobile stations in a GSM system are divided into separate paging groups.

In both cases, in time slot sharing and in separate use, increasing packet radio traffic in the cell may be served better by allocating, when need increases, more time slots to packet radio service.

Example 1

A situation is examined in which circuit switched connections are not in use. In this case, all time slots are allocated to packet radio service. The timing requirements of a packet radio channel are very strict. When a mobile station transmits a request for the transmission of a packet, the base station system must reserve a time slot for this mobile station within a few hundreds of milliseconds, or even faster. For this reason there must always be channel capacity available for packet radio service.

In a cellular network, calls are set up much more slowly. Normally a call is set up within about 3-5 seconds. When the base transceiver station detects signaling required for the setting up of a mobile-originated or mobile-terminated circuit switched call, one of the packet radio channels can be reserved for such a circuit switched call. Normally the maximum transmission time within one and the same reservation in packet radio service is limited. It is a reasonable assumption that the transmission time is below 1 second. If there is transmission on all of the packet radio channels, or on only one of them, the transmission of the packet is completed before the same channel needs to be allocated to circuit switched use. However, a number of time slots must be reserved for packet radio service, these time slots being always available for this service so that a certain minimum level of service can be guaranteed in the cell. This may be a parameter adjustable at the base transceiver station. The operator may adjust this parameter on the basis of the amount of traffic and

economic calculations. When a circuit switched call has been completed, the channel is again released for packet radio service.

By means of this algorithm, rapid packet transmission can be accomplished without disturbing circuit switched traffic. The capacity for circuit switched traffic may be increased when the number of time slots reserved for packet radio service exceeds the minimum capacity indicated by the parameter.

The adjustment of the above-mentioned parameter could, of course, also be automated, for example on the basis of the traffic requirement measured by the base transceiver station, as described below.

In a normal operating mode, all the channels on one carrier wave (in GSM, eight time slots or channels in one burst) are reserved for packet radio services (GPRS). The signaling channels may be on a separate carrier wave or in certain allocated time slots, and the logical channels on the GPRS carrier waves. Mobile stations use the conventional signaling of the mobile telephone system for call set-up. From call set-up signaling the base station system (BSS) detects that a call is arriving in the cell. The base transceiver station detects this after a mobile station has transmitted to it a Channel Request, which is signaled by the base transceiver station (BTS) to the base station controller (BSC) in a Channel Required message. The base station controller of the base station system checks whether there are free traffic channels, whereupon a channel in the use of packet radio service is released for circuit switched calls as follows. If a free traffic channel is found, the mobile station is given a free channel as soon as it needs a channel. If a free channel is not found, reallocation of the packet radio channel is initiated and the channel is allocated to circuit switched use immediately when needed.

The base station system needs a channel before it transmits an Assignment Request to the mobile station. The system will have ample time to reallocate the channel before the transmission of the Assignment Request. Within the time

between the Assignment Request and the Channel Required message, signaling takes place on the signaling channel, in which case the channel in the use of packet radio service can be used until the Channel Required message is transmitted. After the channel has been taken into the use of circuit switched service and after the circuit switched call is completed, the channel is free and is reallocated to packet radio service.

The base station system keeps the mobile station informed of the division of radio capacity, i.e. transmits to the mobile station information as to which channels are in the use of which service (i.e. it transmits information regarding so-called channel configurations).

The checking of capacity and the channel deallocation, according to the invention, between packet radio and circuit switched services may be especially necessary in the case of handover, i.e. when a mobile station moves from one cell to another cell, where, for example, all channels are in the use of packet radio service. In this case the capacity checking and channel reallocation, described above, are preferably carried out after the base station system has received from the mobile station a Handover Request and before the base station system transmits to the mobile station a Handover Request Acknowledgement. In other respects the handover procedure is defined in the specifications of the mobile system and is therefore known to an expert in the art and is not described here in greater detail.

Example 2

The following situation is examined as another alternative. A certain minimum service level is required in a cell. For example, one time slot could always be reserved for packet radio service. The other time slots are used for circuit switched services, or they are free. The base transceiver stations measure the quantity of traffic transmitted on the packet radio channel. Of course, the channel allocation behavior in a cell must be examined carefully before

application, for example on the basis of traffic measurements of the cell concerned or on the basis of history data obtained from corresponding cells elsewhere. In the utilization of a channel there is a certain percentage limit, and at a utilization ratio higher than this the channel becomes overloaded and the service level weakens. If the utilization ratio of a channel reaches this value, another time slot must be reserved for traffic. This can be applied to even eight time slots within one GSM carrier wave and even to multiple carrier waves.

When the utilization ratio of a channel decreases and reaches another, lower, level, one of the time slots in packet radio use can be deallocated.

The algorithm according to this second alternative gives a higher priority to packet radio service, and circuit switched services can use the capacity not required by packet radio services.

The determination of the threshold values may be based on long-term follow-up of traffic. Alternatively it may be variable in such a manner that by using the measuring results obtained within a specified past time period the threshold values are updated regularly.

Example 3

The following case is discussed as one further alternative. A certain service level, which may be quite low, is always offered in a cell. A mobile station may make a request to the channel control block for a few time slots, one or several. On the basis of this request the base transceiver station allocates more time slots to packet radio service. One channel must, of course, be allocated very rapidly to the mobile station. In this case additional channels cannot be reserved immediately. The mobile station is given the basic channel. During the Assignment Request concerning the subsequent packet the network has had enough time to allocate multiple channels to packet radio service. Thus the

mobile station may gain access to the additional capacity it requested initially, i.e. multiple time slots for transmission.

Example 4

One further alternative is discussed below. In a rural area the allocation of even one time slot, or part of a time slot, for packet radio service may be excessive if, for example, in the area there is only one mobile station, which transmits data once a week. In this case no basic capacity for packet radio service needs to be reserved in the cell.

When the mobile station needs to transmit packet data, it transmits a message to that effect to the network. Since now no free packet radio channels are available, the message may be transmitted on conventional signaling channels which are used for circuit switched services. The message may also be transmitted on other signaling channels, traffic channels or as a short-message output.

Example 5

The above examples 1 and 2 can be used in combination so as to ensure that both circuit switched services and packet radio services share the channel capacity in a "fair" manner. This means that a certain channel capacity is allocated to the use of both services according to a semi-fixed principle, and the services use other channels by using a combination of the algorithms of Examples 1 and 2 so that congestion situations with respect to packet radio services will be under control.

The base transceiver station transmits via control channels information to the mobile stations so that they can compete for channels, and also that the access into the network by mobile stations using low priority packet radio service could be prevented until more channels are available.

The present invention includes any novel feature or combination of features disclosed herein either explicitly or any generalisation thereof irrespective of whether or not it relates to the claimed invention or mitigates any or all of the problems addressed.

In view of the foregoing description it will be evident to a person skilled in the art that various modifications may be made within the scope of the invention.

CLAIMS

1. A method for dynamic division of radio capacity between packet radio service and circuit switched service in a TDMA system in which two-way traffic between base transceiver stations and mobile stations takes place in time slots on predetermined channels, characterized in that
- in the basic mode a first predetermined number of time slots are reserved for packet radio service and a second predetermined number of slots are reserved for circuit-switched service, and that
- on the basis of a predetermined criterion, one or more additional free time slot/slots is/are allocated to packet radio service and/or circuit switched service, a corresponding number of time slots being deallocated from the other service.

2. A method according to Claim 1, characterized in that the said first number of time slots comprises all time slots of a channel when circuit switched service does not require capacity, no time slot being reserved for circuit switched service, but one or multiple free time slot/slots is/are allocated to circuit switched service when a predetermined criterion is fulfilled.

3. A method according to Claim 1, characterized in that the said first number of time slots comprises a predetermined minimum number of time slots, in which case, on the basis of the said criterion, one free time slot is first allocated to packet radio service and during the assignment of the subsequent packet the necessary number of additional time slots are allocated.

4. A method according to Claim 3, characterized in that the said minimum number is adjustable, in which case the number is adjusted on the basis of traffic and/or factors of traffic economy.

5. A method according to any of the above claims, characterized in that the said predetermined criterion is a request received from a mobile station, the request requesting network capacity for packet radio service or for circuit switched service.

6. A method according to Claim 5, characterized in that the said predetermined first number of time slots is 0 (zero), in which case a mobile station, in order to have access to packet radio service capacity, makes a request for it to
the base transceiver station.

7. A method according to Claim 1, characterized in that the said predetermined criterion is a threshold value obtained by traffic measuring occurring at the base transceiver station and that, when the traffic of the service concerned increases to above the predetermined first threshold value, one or more additional time slot/slots is/are allocated to this service and, when the traffic of the service concerned drops to below the predetermined second threshold, a corresponding number of time slots are deallocated from this service.

8. A method according to Claim 7, characterized in that the service concerned is packet radio service and that additional time slots are allocated, when necessary, from multiple channels.

9. A method according to Claim 7 or 8, characterized in that the determination of the threshold values is based on long-term measurement of the behavior of the traffic and/or that the threshold values are adjusted on the basis of the traffic measurement result over a specified time period.

10. A method according to any of the above claims, characterized in that the method is applied in parallel also to FDMA bands.

11. A time division multiple access (TDMA) mobile system which comprises a base station system (BSS) comprising base transceiver stations and base station controllers, as well as mobile stations, and in which two-way traffic between the base transceiver stations and mobile stations takes place in time

slots on pre-determined channels and in which mobile system there is packet radio service and circuit switched service, characterized in that, for dynamic division of radio capacity between packet radio service and circuit switched service,

- in the basic mode the base station system (BSS) reserves for packet radio service

a predetermined first number of time slots and for circuit switched system a predetermined second number of time slots,

- the base station system monitors the capacity required for each service, and
- allocates to packet radio service and/or circuit switched service, on the basis of

a predetermined criterion, one or more additional free time slot/slots, deallocating

a corresponding number of time slots from the other service.

12. A mobile system according to Claim 11, characterized in that the base station system transmits to a mobile station information regarding the division of radio capacity between packet radio service and circuit switched service.

13. A radio system in which channels between a base station and a mobile unit are utilised in plural modes, wherein the allocation of channels for utilisation in respective ones of the modes is dynamic such that channels allocated for use in a first of the modes are reallocatable for use in a second of the modes.

14. A method for allocating the mode of usage of channels in a radio system in which channels between a base station and a mobile unit are utilised in plural modes, the allocation of channels for utilisation in respective ones of the modes being dynamic such that channels allocated for use in a first of the modes are reallocatable for use in a second of the modes.

15. A radio system substantially as hereinbefore described with reference to the drawing.

16. A method for allocating the mode of usage of channels in a radio system substantially as hereinbefore described with reference to the drawing.

The Patent Office

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Application No: GB 9600378.5 **Examiner:** David Midgley
Claims searched: 1-16 **Date of search:** 8 March 1996

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Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): H4L (LDG,LDSX,LDLX)

Int Cl (Ed.6): H04L 12/56; H04Q 7/20,7,22,11/04

Other: ONLINE:WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB 2258368 A	(Motorola) See, for example, page 11, lines 6-15.	13,14
X	GB 2232562 A	(Philips) Whole document.	"
X	GB 2232326 A	(Philips) Whole document.	"
X	GB 2217149 A	(Motorola) Whole document.	"
X	EP 0629064 A1	(Thomson) Whole document.	"
X,P	WO 95/21492 A2	(Motorola) See, for example, page 7, lines 9-33.	1,11,13,14 at least
X,P	US 5396539	(NovAtel) Whole document.	"

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.